The comparison of small scale temperature variability in the Western Mediterranean during late winter and late summer

by

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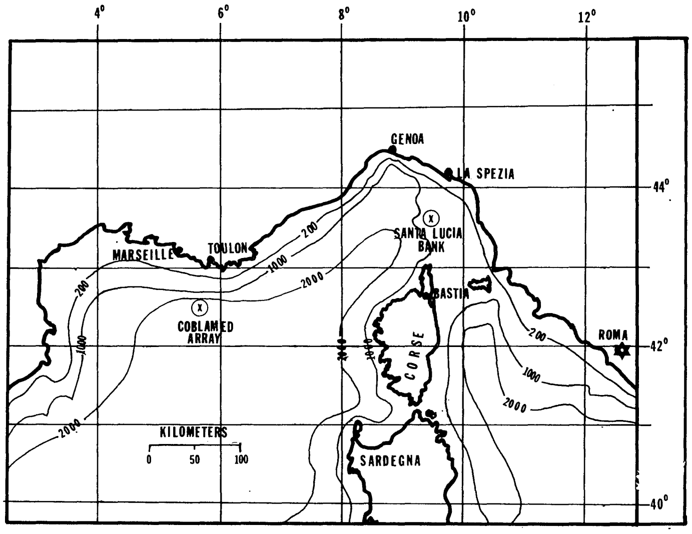
Introduction

Recent observations indicate that in the upper ocean, substantial fluxes of heat, kinetic energy and momentum are associated with intermittant short term events which produce phenomena of small, or meso, scales [MUNK & GARRETT, 1973]. These phenomena can occur in the form of local current shears patchiness, local fronts of temperature and internal wave oscillations.



The majority of oceanic observations of dynamic phenomena have concentrated on horizontal scales of 10-100 kms e.g., (BOMEX and MODE). There is, moreover, a lack of information of oceanic variability on scales between 10 m-10 km.

This report discusses two sets of observations of small scale variability in the upper layers of the western Mediterranean; (1) a time series of temperature profiles made in Mar/69 on the St. Lucia Bank, a seamount located SSW of La Spezia (Fig. 1) and (2) a series of thermistor buoy measurements (COBLAMED - 69) obtained in Sep/69 around the Bouée Laboratoire (BL) in (Fig. 1). [SHONTING, *et al*, 1972*a*].

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These observations are examined in terms of the mechanisms causing variability; namely wintertime advection in the mixed layer over St. Lucia Bank contrasted with oscillations of the late summer layer in the COBLAMED area.

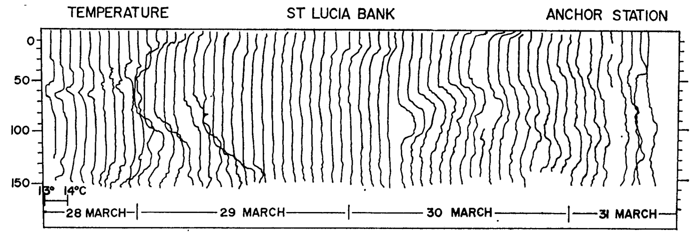
St. Lucia Bank Observations - Late Winter : The St. Lucia Bank is a steep seamount rising up to 125 m [SHONTING & BARTOLINI, 1971]. Observations consisted of hourly temperature/salinity profiles and currents at 30 and 110 m taken while the ship was anchored. The 65 hours of profiles (Fig. 2) indicate inflections of structure which increase and fade with time.

The plot (Fig. 3) indicates the complicated isotherms as being advected by the current similar to that described by the TAYLOR hypothesis for transport of turbulence by a mean flow. The currents at 30 and 110 m averaged 22 cm/sec and remained steady. Therefore, the bottom scale transforms time into space for estimating the dimensions of the blobs of water distinguished from the mixed regions. A lens appears on 30 March between 60 and 110 m which is about 7 km long and 50 m thick.

Spatially distributed temperature stations taken on the seamount running N-S and E-W verifies that the Eulerian variability is caused by advection at the observed mean velocity.

COBLAMED Observations - Late Summer : The experiment consisted of two thermistor buoys (Delta and Echo), one taut moored and the second tethered - first at 100 m and then 400 m giving two 18 hour time series. Each buoy containing a chain of 20 thermistors from 5 m to 60 m in depth which were electronically scanned to provide temperature profiles each 3 minutes. [SHONTING *et al.*, 1972*b*].

FIG. 2



In the temperature records (Fig. 4) of buoys Delta and Echo the vertical bar indicates the time when the separation was changed from 100-400 m. The records seem identical; near surface fluctuations show diurnal heating, the records below 4-5 m show oscillations and are closely correlated between Delta and Echo at both 100 and 400 m. There is a filtering effect where temperature fluctuations below 3 m smooth out with time. This is caused downward progressive mixing from winds increasing from 3 m/sec to 20 m/sec by the end of the record.

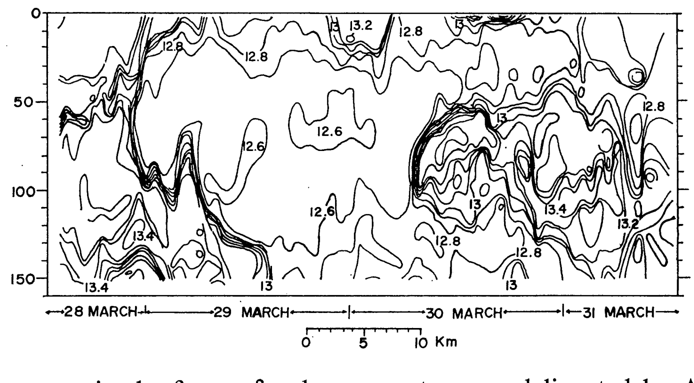


Fig. 3

Thermal events occur in the form of pulses; e.g., two are delineated by A and B. The thermal events are reproduced in Echo almost as they previously appear in Delta. When these traces at 4 m are amplified it is seen that event A occurs at Echo and Delta at about the same time with the 100 m separation. However, when records of the 400 m separation are superposed event Bs arrival at Echo lags B at Delta by approximately 25 minutes; this gives an advection velocity $\sim$ 30 cm/sec. Current records ranged from 25-30 cm/sec [SHONTING, 1974]. The correlation coefficient was calculated for the 100 and 400 m separation for the pairs of sensors at identical depths; the correlations were very high, almost 1.0 at the surface. This was caused by the diurnal heating wave which is uniform horizontally. The higher correlations quickly diminish below the surface layer but increase again at the points of the strongest temperature gradient at 5 m and at 35 m.

A cross spectral coherence diagram for 1 m and 35 m is shown (Fig. 5) for the 100 and 400 m separation with 20 degrees of freedom. Both coherences fall of quickly below 100 min., the 100 m decreasing faster. This is due to the surface mixed layer 3-5 m deep which formed during the 400 m experiment because of high wind conditions which were not present during the 100 m separation experiment. The coherence values for the sensors at 35 m depth curve remains large out to 20 min. period whereas the 400 m coherence falls of rapidly. It appears that the oscillations probably associated with internal waves have characteristic lengths shorter than 400 m but greater than 100 m in the range of periods between 20 to 200 min.

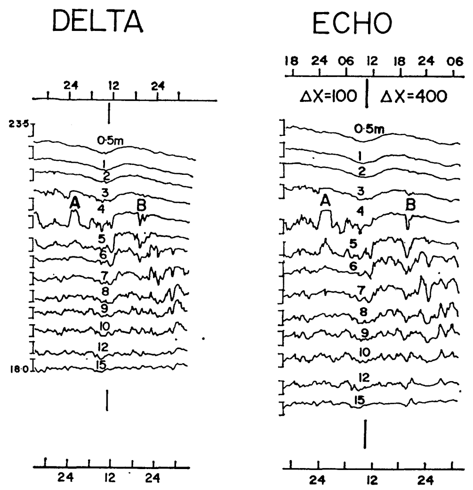
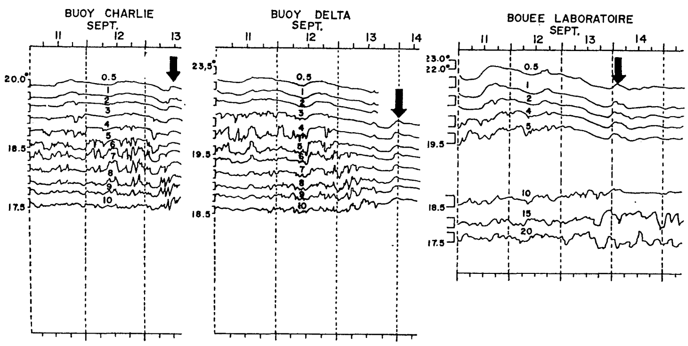


Fig. 4

Observation of larger scale advected events : The Delta Echo experiment provided records of pulses moving ostensibly " down stream " which span time intervals of 20 to 30 min. Phenomena was then only detected 2 points parallel to the mean flow. Thus, we can make no judgment of the extent of the lateral scale of the phenomena. It is of interest to inquire as to whether such events are distributed in the ocean on larger scales. In order to examine this possibility records from the 8½ km COBLAMED array were examined for thermal events possibly identifiable at each of the buoy positions. Such phenomena were observed.

Record Charlie (Fig. 5A) shows a thermal pulse (black arrow) at about 2400 on 13/Sep Delta record (Fig. 5B) a thermal event occurs at 2000 on 13/Sep. The third temperature pulse is seen at 1000 (Fig. 5C). Here the peak is almost identical in shape and amplitude to that recorded at Delta.

FIG. 6



The question arises, are these three similar temperature signals related to the same phenomena? There was no evidence that the heating pulses were caused by local air/sea interaction processes. It is suggested that this phenomena was advected with a mean current and perhaps associated with a single wave-like pulse of front propagating horizontally much like the phenomena we discussed of A and B on the Delta Echo experiment. By geometric analysis using arrival times and buoy positions we find that the events propagated as a line disturbance, moving at 5 cm/sec in the direction of 310°, currents at buoys Bravo and Charlie were roughly 20 cm/sec at 290° and 18 cm/sec at 200°. Since the currents are not uniform in the COBLAMED area our assumption of a linear front propagating through the triangle is in doubt, however, since the general motion is toward the east coinciding roughly with the advance of the pulses it is probable that this was advected frontal phenomena whose lateral scale exceeded the buoy separation of 8.5 km.

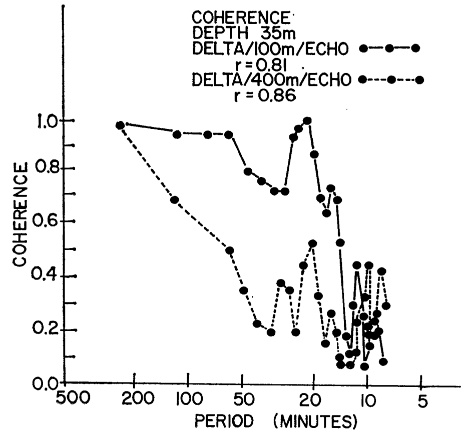


Fig. 6

The results of examinations of St. Lucia Bank and COBLAMED indicate that the very nature of oceanic variability is strongly dependent upon the intensity/strength of the ambient density stratification. In the wintertime in a semi-mixed layer condition the horizontal gradients are much larger relative to the vertical gradients than in the summer and that the mean currents advect the variability observed at fixed depths. In the summertime the temperature variability is essentially caused by vertical oscillations of internal waves and to a lesser degree by advected processes.

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